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Enclosure 2

ENCLOSURE 2

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Nuclear

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LICENSING TOPICAL REPORT

ESBWR MARATHON CONTROL ROD – MECHANICAL DESIGN REPORT

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1 INTRODUCTION

The GE Marathon control rod design for ESBWR is defined in Reference 1 drawing. The control rod is composed of the absorber section, handle and connector as shown in Figure 1.1. The connector is similar to those used in other control rod designs for ABWR reactors.

The absorber section of the control rod has four wings of 13 high purity 304 stainless steel square tubes each. The "square type" absorber tubes used in this design have four "lobes" to allow welding of adjacent square tubes together. [[

]] The absorber tubes are welded lengthwise together to form the four absorber section wings with a tie rod down the centerline. The four absorber section wings are loaded [[

]]. The absorber section welding is helium leak checked to assure a complete weld. The handle and connector are welded to the absorber section to form the cruciform-shaped control rod shown in Figure 1.1. In addition to containing absorber material, the absorber tubes are load carrying members.

The absorber tubes in the ESBWR control rod design maintain absorber material within a 114"[2896mm] nominal absorber zone length. [[

]]

The ESBWR control rod is 132"[3353mm] in length and weighs approximately 164lbs[75kg].

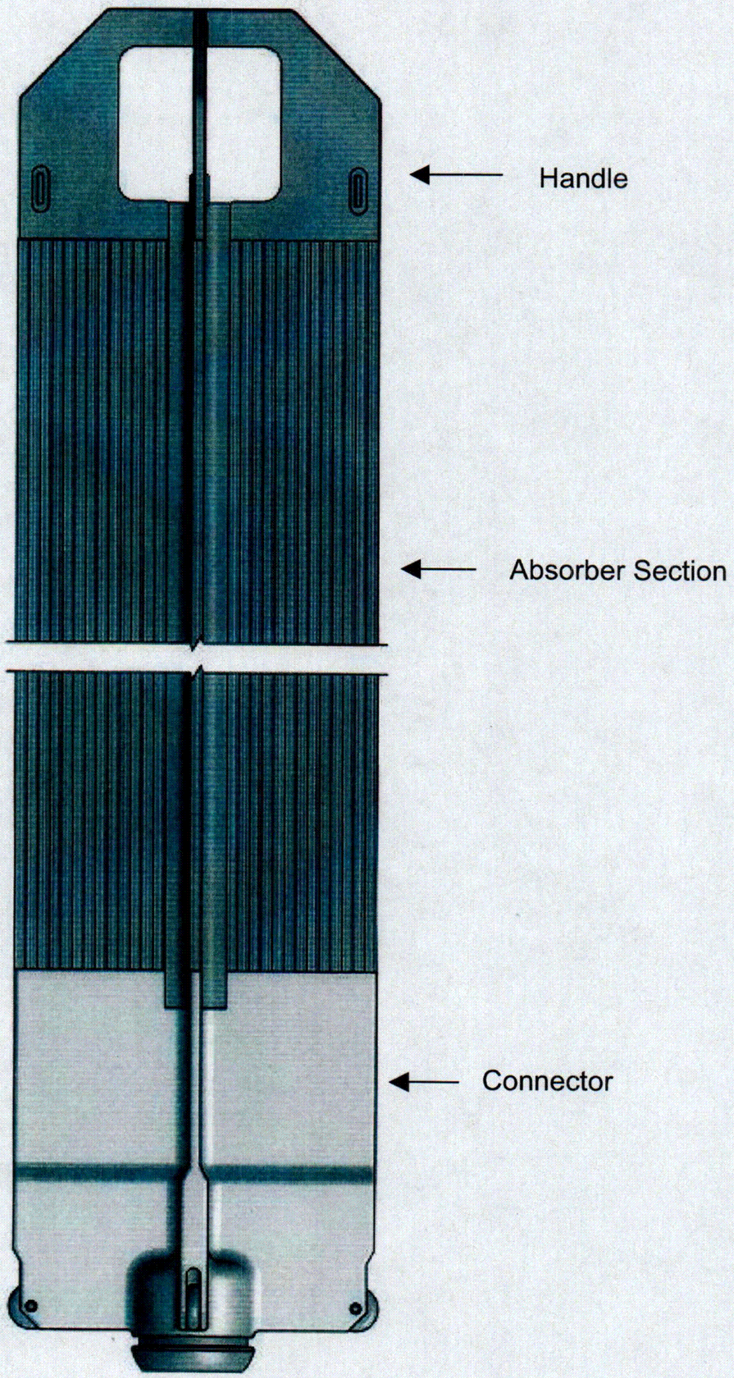

Figure 1.1: Typical ESBWR Control Rod

[[

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Figure 1.2: Configuration of Absorber Material within the Absorber Section Wing

2 ANALYSES SUMMARY

All control rod components are found to be acceptable in accordance with Reference 2 criteria when analyzed due to internal and external loads.

External load sources such as SCRAM, seismic, FMCRD (Fine Motion Control Rod Drive), excessive channel bow, handling and reactor pressure were analyzed, as well as internal load sources from B_4C absorber material burn-up such as thermal gradients, internal pressure due to B_4C gas release and strain due to B_4C swelling. Combinations of the load sources were also reviewed.

Sections analyzed for internal and external load stresses and strains are illustrated in Figure 2.1 and summarized in Table 2.1. The supporting analyses to obtain the stresses and/or strains are given in Sections 7 through 14.

The mechanical life of the control rod absorber tubes are found to be limited [[

]], the nuclear lifetime is more limiting than mechanical lifetime.

All calculations are performed using the English system then the final result is converted to the SI system for reference.

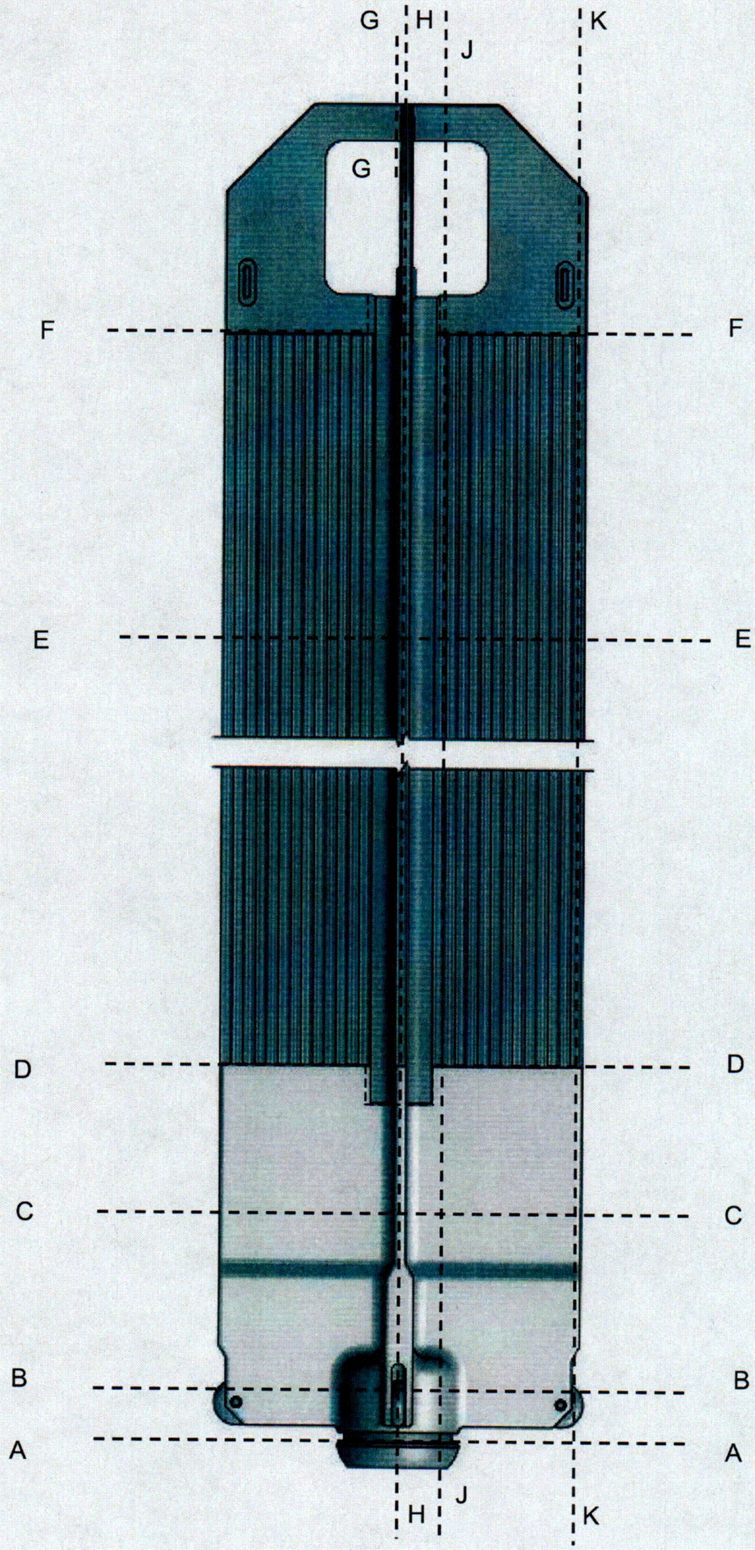

Figure 2.1: Control Rod Sections Analyzed

C02

Listed in Table 2.1 are either the lowest margin or highest component stresses for a given load source and section. Additional component stresses for a given load source are provided in Section 7.

TABLE 2.1 SUMMARY OF STRESS ANALYSIS

Load Source	Section	Component	Material	Load Type	Temperature	Stress	Ratio
SCRAM	A-A	Socket	XM-19	Bearing	70°F[21°C]	[[	1.36
SCRAM	A-A	Socket	XM-19	Bearing	520°F[271°C]		1.93
SCRAM	B-B	Socket	XM-19	Tensile	70°F[21°C]		< yield str.
SCRAM	B-B	Socket	XM-19	Tensile	520°F[271°C]		< yield str.
SCRAM	C-C	Connector	CF3	Tensile	70°F[21°C]		< yield str.
SCRAM	C-C	Connector	CF3	Tensile	520°F[271°C]		< yield str.
SCRAM	D-D	Horiz. Weld Vert. Weld	Weld	Tensile Shear	70°F[21°C]		< yield str. < yield str./2
SCRAM	D-D	Horiz. Weld Vert. Weld	Weld	Tensile Shear	520°F[271°C]		< yield str. < yield str./2
SCRAM	E-E	Abs Section	304S	Tensile	70°F[21°C]		< yield str.
SCRAM	E-E	Abs Section	304S	Tensile	520°F[271°C]		< yield str.
SCRAM	F-F	Horiz. Weld Vert. Weld	Weld	Tensile Shear	70°F[21°C]		< yield str. < yield str./2
SCRAM	F-F	Horiz. Weld Vert. Weld	Weld	Tensile Shear	520°F[271°C]		< yield str. < yield str./2
Seismic + Channel Bow	K-K	Abs Section	304S	Tensile	70°F[21°C]		< yield str.
Seismic + Channel Bow	K-K	Abs Section	304S	Tensile	550°F[288°C]		2.3
FMCRD	J-J to K-K	Control Rod Wing only	Austenitic SS	Comp-ression	70°F[21°C]		*< yield load
FMCRD	J-J to K-K	Control Rod Wing only	Austenitic SS	Comp-ression	550°F[288°C]		*< yield load
Handling, Lifting	G-G	Handle	316SS	Tensile	70°F[21°C]		< yield str.
RPV Pressure	E-E	Abs Section	304S	Comp-ression	550°F[288°C]		2.6
RPV Press + Channel Bow	E-E	Abs Section	304S	Comp-ression	550°F[288°C]		2.3
Thermal	E-E	Abs Tube	304S	Thermal	550°F[288°C]		< yield str.
Internal Pressure	E-E	Abs Tube	304S	Tri-axial	550°F[288°C]		**2

Load Source	Section	Component	Material	Load Type	Temperature	Stress	Ratio
Internal Swelling	E-E	Abs Tube	304S	Strain	550°F[288°C]		***2.92
SCRAM + Internal Pressure + Channel bow	E-E K-K	Abs Tube	304S	Tri-axial	70°F[21°C]		2.13
SCRAM + Internal Pressure + Channel bow	E-E K-K	Abs Tube	304S	Tri-axial	520°F[271°C]		1.87
SCRAM + Internal Pressure	D-D	Horiz. Weld End Plug	Weld	Tensile Shear	70°F[21°C]		2.62 2.34
SCRAM + Internal Pressure	D-D	Horiz. Weld End Plug	Weld	Tensile Shear	520°F[271°C]		< yield str. 2.15
Seismic + Channel bow + Internal Pressure	E-E J-J	Abs Tube	304S	Tri-axial	520°F[271°C]	]]	1.18

* = Load to cause yielding used as limit (ref. Section 9).

[[

]]

Where the ratio is less than 2, acceptability of stresses is justified through conservative loading as explained in Sections 7 though 14.

Those stresses shown in bold were used in the fatigue evaluation in Section 15.

3 CONTROL ROD MATERIALS AND SECTION PROPERTIES

Information on structural members is listed below with the appropriate materials, section properties and masses if applicable.

3.1 CONNECTOR

The connector assembly is made up of a connector casting with a socket in addition to axles and rollers for guidance.

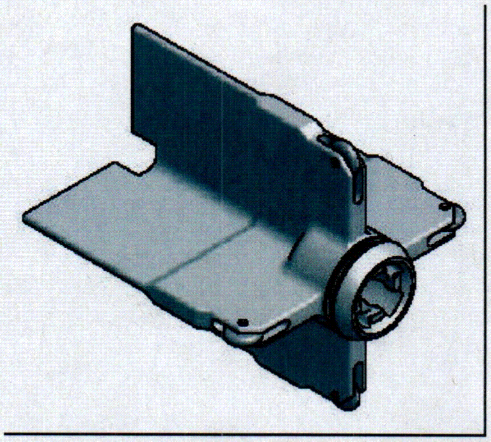

Figure 3.1: Connector Assembly

3.1.1 SOCKET

Material: XM-19 Stainless Steel

Cross Sectional Properties for Figure 2.1

Section A-A - Provided in Section 7.1.

Section B-B

[[

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3.1.2 CONNECTOR CASTING

Material: CF3 Stainless Steel

Sectional Properties for Figure 2.1

Section B-B

[[

C03

]]

Section C-C

Thickness: .312 +/- .010" [7.92 +/- 0.25mm]

[[ ]]

3.2 CONNECTOR TO ABSORBER SECTION WELD

The absorber section is designed so that the absorber section width will not exceed the connector width.

Section D-D

3.2.1 Weld Length

[[

]]

The horizontal Tie Rod to Connector weld is not considered structural and is not considered in the weld length.

3.3 ABSORBER SECTION

The absorber section is made up of square tubes welded into a cruciform shape with a tie rod in the center. [[

]]

Section E-E

[[

]]

3.3.1 SQUARE TUBE

Material: 304 Special Radiation Resistant

[[

]]

3.3.2 TIE ROD

Material: 304 Special Radiation Resistant

[[ ]]

3.3.3 END PLUG

Material: 308L

[[ ]]

3.3.4 CAPSULE

BODY TUBE

Material: 304L

[[ ]]

ABSORBER

Material: Boron Carbide

3.4 ABSORBER SECTION TO HANDLE WELD

The absorber section is designed so that the absorber section width will not exceed the handle width.

Section F-F: The weld length is the same as 3.2.1 above.

3.5 HANDLE

Material: 316 Stainless Steel

Thickness: .312 +/- .005" [7.92 +/- 0.13mm]

Fillet weld size: .16"[4.1mm] minimum

Filler metal material: 308L Stainless Steel

4 MATERIAL PROPERTIES

Ambient and elevated temperature properties are listed in this section. The control rod moves vertically in the reactor and is subject to different reactor operating temperatures depending on the position. Therefore, the elevated temperature properties may be listed as 550°F[288°C] or 520°F[271°C]. Irradiated material properties are displayed for those materials where capability is demonstrated near the end of life.

4.1 304L STAINLESS STEEL

TABLE 4.1

Temperature	Yield Strength (min.)	Ultimate Strength (min.)	Modulus of Elasticity
70°F [21°C]	25ksi [172MPa]	70ksi [483MPa]	28,300ksi [195GPa]
520°F[271°C]	16.2ksi [112MPa]	57.4ksi [396MPa]	26,100ksi [180GPa]

4.2 316 STAINLESS STEEL

TABLE 4.2

Temperature	Yield Strength (min.)	Ultimate Strength (min.)	Modulus of Elasticity
70°F [21°C]	30ksi [207MPa]	75ksi [517MPa]	28,300ksi [195GPa]
520°F[271°C]	--	--	26,100ksi [180GPa]
550°F[288°C]	19.3ksi [133MPa]	71.8ksi [495MPa]	25,800ksi [179GPa]

4.3 ER308L STAINLESS STEEL

TABLE 4.3

Temperature	Yield Strength (min.)	Ultimate Strength (min.)
70°F [21°C]	30ksi [207MPa]	75ksi [517MPa]
520°F[271°C]	19.2ksi [132MPa]	63.4ksi [437MPa]
550°F[288°C]	18.9ksi [130MPa]	63.4ksi [437MPa]

4.4 RADIATION RESISTANT 304S STAINLESS STEEL

TABLE 4.4A – TIE ROD

[[			
			]]

TABLE 4.4B – ABSORBER TUBING

[[				
				]]

[[ ]]

Thermal conductivity, k = 0.6917+0.0004167T, k units = (Btu/hr-in-F)

4.5 XM-19 STAINLESS STEEL

TABLE 4.5

Temperature	Yield Strength (min.)	Ultimate Strength (min.)	Modulus of Elasticity
70°F [21°C]	55.1ksi [379MPa]	100ksi [687MPa]	28,300ksi [195GPa]
520°F[271°C]	--	--	26,100ksi [180GPa]
550°F[288°C]	38.1ksi [262MPa]	80.5ksi [553MPa]	--

The fatigue curve for this material is given in Table I-9.1 of Reference 3.

4.6 CF3 STAINLESS STEEL CASTING

TABLE 4.6

Temperature	Yield Strength (min.)	Ultimate Strength (min.)	Modulus of Elasticity
70°F [21°C]	30ksi [207MPa]	70ksi [483MPa]	28,300ksi [195GPa]
520°F[271°C]	19.2ksi [132MPa]	53.8ksi [371MPa]	26,100ksi [180GPa]

The fatigue curve for this material is given in Table I-9.1 of Reference 3, except elevated temperature uses Table I-9.2.2.

4.7 BORON CARBIDE (B_4C)

4.7.1 DENSITY

A capsule's nominal B_4C density is 1.76 g/cm^3 or 70% theoretical density. A given lot can have a density range of [[ ]]

4.7.2 MOISTURE CONTENT

The worst case moisture content permitted in an absorber tube is [[ ]]

4.7.3 THERMAL CONDUCTIVITY

$k = 0.407[(T-142)/(1183+T)] [\mu /(1.45-\mu)]$, k units = (Btu/hr-in-F)

where: T = Temperature (^{o}F) and μ = boron carbide density fraction (.7)

4.7.4 IRRADIATION

During irradiation the B_4C releases helium gas by the reaction $^{10}B + {}^{1}n \rightarrow {}^{7}Li + {}^{4}He$. A fraction of the released helium is trapped in the B_4C solid matrix and the remaining helium is released as gas. The trapped B_4C causes swelling at a rate determined from experimentation, [[ ]]. The fraction of helium released is dependent on the temperature of B_4C. [[ ]]

Helium thermal conductivity, $k = 0.00683 + 0.0000074T$, k units = (Btu/hr-in-F)

4.8 ENVIRONMENT

4.8.1 EXPERIENCE

The control rod materials are the same materials currently used in GE control rods for BWR reactor environment. These external control rod materials are designed to withstanding the reactor coolant environment for the life of the control rod. Depending on the how the control rod is positioned in the core, the lifetime may be a few years for high fluence locations, or the lifetime may be for the life of the plant as some original equipment control rods are experiencing in BWR/2-4 reactors.

No material has experience for a BWR 60 year lifetime, although the experience with the austenitic stainless steels in withdrawn BWR/2-4 original equipment control rods (approximately 30-35 years) to date has been favorable in structural locations such as the handle, tie rod and drive connection piece.

Experience has shown the absorber tube material in paragraph 4.4 has the capability of withstanding the reactor coolant environment, in high fluence locations with B_4C swelling, for up to 4.8 snvt with no indications. [[ ]]

4.8.2 STAINLESS STEEL IRRADIATION

Irradiation causes the stainless steel material strength to increase so material strength limiting conditions are nearly always encountered with unirradiated material. Therefore, irradiation affect upon the material is only included in the absorber tube evaluations where internal loads

due to localized B_4C swelling causes a condition not encountered by lower strength unirradiated properties.

4.8.3 STRESS CORROSION

Stress corrosion cracking in control rods is normally caused by crevices and tensile stresses from B_4C swelling. The crevice corrosion affect the ESBWR control rod has been significantly reduced by eliminating crevices compared to previous designs. [[

]]

4.8.4 CRUD

Maximum crud build up was assumed to be [[ ]] for a control rod that would be depleted over a few cycles or a control rod that would reside in the guide tube as serve as a shut down control rod for most of the control rod lifetime.

Crud thermal conductivity, [[ ]]

5 DESCRIPTION OF CONTROL ROD LOADING

The control rod is evaluated to assure that it does not fail because of loads due to shipping, handling, normal operation, including the effects of anticipated operational occurrences (AOOs), infrequent incidents and accidents (Reference 2). The loads evaluated include those due to normal operational transients (scram and jogging), pressure differentials, thermal gradients, flow and system induced vibration, and irradiation growth in addition to the lateral and vertical loads expected for each condition. The analyses include corrosion and crud deposition as a function of time, as appropriate. Conservatism is included in the analyses by including margin to the limit or by assuming loads greater than expected for each condition.

The control rod is evaluated to be sure that it can be inserted during normal operations including the effects of AOOs, infrequent incidents and accidents.

5.1 SCRAM

The dynamic loads on the control rods are bounded by the fine motion control rod drive (FMCRD) imposed loads (scram loads) in the vertical direction. The ESBWR inoperative buffer loads are the highest vertical loads experienced by the control rod due to the high terminal velocity. The number of scram events over the life of the plant is expected to be approximately 130.

5.1.1 MODEL

A Control Rod Drive Housing (CRDH), Fine Motion Control Rod Drive (FMCRD) and control rod composite dynamic model was created for input into the ECP (Engineering Computer Program) SEISM. The dynamic model represents the CRDH, FMCRD and control rod as a series of mass, springs, gap and damping elements for analysis. The FMCRD assembly dynamic model simulates a representation of all load bearing components of the assembly during a scram event. The control rod assembly model, which included a simplified representation of the control rod, was formulated to determine the loadings in the control rod components during a scram condition.

[[

]]

The control rod spring elements elastically connect the mass elements in the control rod analytical model. The spring stiffnesses were calculated by AE/L (area x modulus of elasticity / length of the element). Where two spring elements act in parallel to support the structure the spring stiffnesses were added together, for example, the tie rod mass and absorber tube mass elements in the absorber section. Where the two spring elements acted in series to support the

structure, a composite spring stiffness was obtained by the reciprocity law, for example, the tie rod mass to handle mass spring element. The stiffness was calculated [[
]]

The gap elements were placed where the control rod is elastically disconnected. The gap elements were made up of a spring and a gap in series between two mass nodes. The gap elements were also limited by the gap clearances. [[
]].

The control rod damping elements are placed by ECP SEISM to act in parallel to the spring and gap elements. When creating the model, the structural damping in the analysis is taken as [[
]].

5.1.2 INPUT

An input file was created for running on the ECP SEISM program. The engineering computer program (ECP) SEISM model was run at cold temperatures speeds and properties (i.e. modulus) as well as elevated temperature speeds and properties. The velocity was changed depending on the state of operation and the buffer. [[ ]] was used at room temperature for an inoperative buffer, [[ ]] was used at elevated temperature for an inoperative buffer. The gaps between the absorber section contents and handle were varied to determine the largest impact.

5.1.3 LOAD CALCULATION

ECP SEISM was used to calculate the loads on each spring and gap element. The ECP SEISM is a nonlinear, discrete finite element, time history analysis program which accounts for geometric nonlinearities (i.e., gap and friction elements) in the elastic continuum. The code is based on minimum energy and variational principles and the resulting coupled, nonlinear differential equations of motion are solved by a step-by-step direct integration with respect to time. [[
]]

5.1.4 RESULTS

[[

]]

TABLE 5.1: COMPONENT LOADS FROM DYNAMIC ANALYSIS

Component	Load Cold	Load Hot
Socket	[[	[[
Connector		
Connector/Absorber Section		
Absorber Section		
Absorber Section / Handle		
Capsules	]]	]]

(+) represents compression, (-) represents tension

[[

]]

5.2 SEISMIC

Fuel channel deflections, which result from seismic and LOCA events, impose lateral loads on the controls rods. The Marathon control rod is analyzed for Safe Shutdown Earthquake (SSE) events. The expected ESBWR seismic deflections were obtained from Reference 5 Table C-22.

Channels bow during the course of the fuel life, which may cause interference with the control rod. Channel deflection based on previous experience with BWR/6 reactors was taken into consideration and then estimated for ESBWR.

During a seismic event, it is assumed that seismic deflections could be added to any preexisting channel bow. The channel bow condition is assumed to be present at any time, although the seismic deflection is postulated as a 2 time occurrence, 10 peaks each for a total of 20 cycles.

TABLE 5.2: FUEL DEFLECTIONS

SSE Seismic Deflection	[[
Channel Bow Deflection	
TOTAL	]]

5.3 FMCRD

The FMCRD has the capability to exert force on the control rod during insertion.

TABLE 5.3: FMCRD INSERTION LOADS

RPV Pressure	Force
0 psi [0 MPa]	8.07 kips [35.9kN]
1250 psi [8.6 MPa]	3.64 kips [16.2kN]

5.4 REACTOR PRESSURE

The RPV core zone normal pressure is 1050psi [7.24MPa] at 552°F[289°C].

5.5 BURN-UP

The square tube is designed accommodates loads created by the neutron irradiation of the absorber material.

5.5.1 THERMAL

The temperature in the absorber tube increases due to absorber tube material irradiation. The peak B_4C tube heat generation is listed in Reference 4. The heat coefficient is determined between the crud thickness and RPV coolant based on the heat transfer rates, RPV pressure and temperature. ANSYS models were created to represent nominal and worst case square tube and capsule geometry with appropriate crud thickness and material conductivities.

[[

]]

Figure 5.1: Absorber Tube Thermal Model.

[[

]]

TABLE 5.4: ABSORBER TUBE BEGINNING OF LIFE OPERATING TEMPERATURES

[[		
		]]

[[

]]

5.5.2 INTERNAL PRESSURE

Internal pressure builds within the absorber tube during the control rod lifetime. A computer code is used to determine the tube pressurization in terms of average B_4C depletion. The axial depletion profile is provided in Reference 4.

[[

]]

[[

]].

Figure 5.2: Absorber Tube Pressure vs B10 Depletion for Nominal Conditions.

[[

]]

5.5.3 SWELLING

[[

]] As the B_4C is irradiated helium is trapped in the B_4C matrix the B_4C capsule begins to expand. [[

]]

TABLE 5.5: SWELLING DATA

[[

]]

[[		
		]]

[[

]]

5.6 COMBINATIONS

The ESBWR Marathon is subject to load combinations of anticipated operational occurrences (AOOs). Listed below are reasonable load combinations during control rod lifetime based on the external and internal loads above.

5.6.1 COMBINATION 1

Absorber tube loads are evaluated during a SCRAM, in a cell with channel bow near end of control rod life when absorber helium gas build-up is highest.

5.6.2 COMBINATION 2

Absorber section to connector welds and absorber section to handle loads are evaluated during a SCRAM when absorber helium gas build-up is highest.

5.6.3 COMBINATION 3

Absorber tube loads are evaluated during a seismic event near the end of control rod life when absorber helium gas build-up is highest.

6 DESIGN CRITERIA

6.1 Stress and Strain

The control rod stresses, strains, and cumulative fatigue are evaluated to not exceed the ultimate stress or strain limit of the material (ref. 2).

Control rod materials are considered ductile and are evaluated [[ ]]For stress during plastic deformation [[ ]]. For those conditions where the geometrical tolerances or other input ranges are not reviewed within the analysis, a safety factor of 2 shall be used or an explanation of the loading conservatisms.

6.2 Fatigue

Fatigue is evaluated not to exceed a fatigue usage factor of 1.0. Fatigue usage is based upon the cumulative effect of the cyclic loadings.

6.3 Mechanical Lifetime

Per Reference 6, when the lifetime of a control rod is not limited by nuclear affects (i.e. control rod that is normally fully withdrawn from the core), the mechanical lifetime shall be at least 13 years. When a control rod or a portion of the control rod remains in the core, the analysis number of cycles shall be 25% of the number defined in the reactor cycles drawing.

6.4 Control Rod Insertion

The control rod is evaluated to be capable of insertion into the core during all modes of plant operation within the limits assumed in the plant analyses.

The evaluations include a combination of analyses of the geometrical clearance and actual testing. The analyses consider the effects of manufacturing tolerances, swelling and irradiation growth. Tests may be performed to demonstrate control rod insertion capability for conditions such as control rod or fuel channel deformation and vibrations due to safe shutdown earthquakes.

For SSE, the control rods are specified as seismic category 1 (ref. 6) which means the component is required to withstand the effects of an SSE and remain functional (ref. 7). [[ ]]

7 STRESSES DUE TO SCRAM LOADS

The resultant loads from Table 5.1 are evaluated using the material properties and geometry for the area subject to the load. Unless otherwise noted, the resultant stresses are listed in tables below, (+) is tensile, (-) is compressive.

7.1 SOCKET

BEARING LOAD in Section A-A

[[

]]

[[

]]

Figure 7.1: Interface of Connector Socket

$$\sigma_{BEARING} = \frac{F_{SOCKET}}{A}$$

TENSILE LOAD in SECTION B-B

Using the minimum socket area: $\sigma_{TENSILE} = \frac{F_{SOCKET}}{A}$

TABLE 7.1: SOCKET STRESS

LOAD TYPE	TEMPERATURE	[[	ALLOWABLE	RATIO
BEARING A-A	70°F[21°C]		Table 4.5	1.36
BEARING A-A	520°F[271°C]		Table 4.5	1.93
TENSILE B-B	70°F[21°C]		Table 4.5	< yield str.
TENSILE B-B	520°F[271°C]	]]	Table 4.5	< yield str.

The bearing stress ratios to ultimate strength are acceptable due to the nature of the conservative loading explained in Section 5.1.

The socket threads are not considered since the limiting condition for a given engagement thread length will be the lower strength connector casting.

7.2 CONNECTOR CASTING

TENSILE LOAD

Using minimum areas from:

SECTION B-B, $\sigma_{TENSILE} = \frac{F_{SOCKET}}{A}$, and SECTION C-C, $\sigma_{TENSILE} = \frac{F_{CONNECTOR}}{A}$

SHEAR LOAD

Using minimum shear area of internal thread:

$$\tau_{THREADS} = \frac{F_{SOCKET}}{A}$$

TABLE 7.2: CONNECTOR CASTING STRESS

LOAD TYPE	TEMPERATURE	[[	ALLOWABLE	RATIO
TENSILE B-B	70°F[21°C]		Table 4.6	< yield str.
TENSILE B-B	520°F[271°C]		Table 4.6	< yield str.
TENSILE C-C	70°F[21°C]		Table 4.6	< yield str.
TENSILE C-C	520°F[271°C]		Table 4.6	< yield str.
SHEAR B-B	70°F[21°C]		15ksi [103MPa]	< yield str./2
SHEAR B-B	520°F[271°C]	]]	9.6ksi [66.2MPa]	< yield str./2

7.3 CONNECTOR TO ABSORBER SECTION WELD

The scram deceleration load is transferred from the absorber section to the connector through welds as shown in Figure 2.1, the square tube to connector and tie rod to connector welds.

Treating the weld as a line, the load "*f*" is expressed in kips/in[kN/mm].

[[

]]

Figure 7.2: Connector To Absorber Section Weld Showing Forces On Welds

A = Connector to absorber section weld.
B & C = Connector to tie rod weld.

WELD LENGTH

The minimum weld lengths from Section 3.3 is [[ ]]

WELD SIZE

The minimum weld penetration for B, the connector to tie rod weld, is [[ ]]

The minimum weld penetration for A, the connector to absorber section weld, is [[ ]], although there are irregularities in the absorber tube geometry that reduce the distance to the effective weld penetration.

[[

]]

Figure 7.3: Connector To Absorber Section

[[

]]

MATERIAL

The fusion zone composition will consist of percentages of the base and filler metal depending on the base metal dilution. The allowable stress will be taken as the material with the least strength at a given temperature.

Weld A fusion zone material composition will consist the connector material, end plug material, absorber tube material and ER308L weld filler metal from the seal welds.

Weld B fusion zone material composition will consist the connector material, tie rod material and ER308L weld filler metal.

TENSILE LOAD

Using minimum weld length and effective weld penetration:

$$\sigma_{TENSILE,WELD,A} = \frac{f_{SECTION,D-D}}{weld\_size}$$

SHEAR LOAD

Using minimum weld length and effective weld penetration:

$$\tau_{SHEAR,WELD,B} = \frac{f_{SECTION,D-D}}{weld\_size}$$

TABLE 7.3: CONNECTOR TO ABSORBER SECTION WELD STRESS

LOAD TYPE - WELD	TEMP	*f*	WELD SIZE	MAXIMUM STRESS	ALLOWABLE	RATIO
TENSILE – A D-D	70°F[21°C]	[[				< yield str.
TENSILE – A D-D	520°F[271°C]					< yield str.
SHEAR – B D-D	70°F[21°C]					< yield str./2
SHEAR – B D-D	520°F[271°C]				]]	< yield str./2

7.4 ABSORBER SECTION

The following table summarizes the resultant stresses for Section 7.4.

TABLE 7.4: ABSORBER SECTION STRESS

LOAD TYPE	TEMPERATURE	MAXIMUM STRESS	ALLOWABLE	RATIO
TENSILE E-E	70°F[21°C]	[[	Table 4.4A&B	< yield str.
TENSILE E-E	520°F[271°C]		Table 4.4A&B	< yield str.
COMPRESSION E-E	70°F[21°C]		Table 4.1	< yield str.
COMPRESSION E-E	520°F[271°C]	]]	Table 4.1	< yield str.

7.4.1 Absorber Tubes and Tie Rod

TENSILE LOAD

Using minimum area from section E-E:

$$\sigma_{TENSILE} = \frac{F_{ABSORBERSECTION}}{A}$$

7.4.2 Capsules

[[

]]

7.4.3 End Plug Weld

See Absorber Section to Handle Weld.

7.5 ABSORBER SECTION TO HANDLE WELD

Most of the scram deceleration load is transferred from the absorber section contents [[ ]] to the handle weld, the remaining load is from the handle mass. The load is transferred [[ ]] to the handle and absorber tube as shown in Figure 7.4.

Treating the weld as a line, the load "f" is expressed in kips/in[kN/mm].

[[

]]

Figure 7.4: Handle To Absorber Section Weld Loads And Reactions

A = Handle to absorber section weld.
B = Handle to tie rod weld.

WELD LENGTH

The minimum weld lengths from Section 3.3 [[ ]]

WELD SIZE

The minimum weld penetration for B, the handle to tie rod weld, is [[ ]]

The minimum weld penetration for A, the handle to absorber section weld, is [[ ]], although the load path due to capsule impact and irregularities in the square tube geometry alter the effective weld penetration.

Figure 7.5A is a side view of the load path in weld A from Figure 7.4. [[

]]

[[

]]

Figure 7.5: Absorber Section To Handle and End Plug Welds, 7.5A On Left 7.5B on Right

[[

]]

MATERIAL

The fusion zone composition will consist of percentages of the base and filler metal depending on the base metal dilution. The allowable stress will be taken as the material with the least strength at a given temperature.

Weld A fusion zone material composition[[ ]] will consist the handle material, end plug material, square tube material and ER308L weld filler metal from the seal welds.

Weld B fusion zone material composition will consist the handle material, tie rod material and ER308L weld filler metal.

TENSILE LOAD

Using minimum weld length and effective weld penetration:

$$\sigma_{TENSILE,WELD,A} = \frac{f_{SECTION,F-F}}{weld\_size}$$

SHEAR LOAD

Using minimum weld length and effective weld penetration:

$$\tau_{SHEAR,WELD,B} = \frac{f_{SECTION,F-F}}{weld\_size}$$

TABLE 7.5: HANDLE TO ABSORBER SECTION WELD STRESS

LOAD TYPE - WELD	TEMP	f	WELD SIZE	MAXIMUM STRESS	ALLOWABLE	RATIO
TENSILE – A F-F	70°F[21°C]	[[				< yield str.
TENSILE – A F-F	520°F[271°C]					< yield str.
SHEAR – B F-F	70°F[21°C]					< yield str./2
SHEAR – B F-F	520°F[271°C]				]]	< yield str./2

8 STRESSES AND STRAIN DUE TO SEISMIC LOADS

During seismic deflections, the control rod is assumed to contact the fuel channels at the handle, the mid-span and the lower roller. The deflection is about the axial centerline of the control rod, i.e. section H-H in Figure 2.1. Table 5.2 summarizes the maximum control rod centerline deflections due to channel bow, seismic, and combined displacements.

[[

]]

For seismic deflection only, the term $y_{o,max}$ is replaced by the centerline Safe Shutdown Earthquake (SSE) deflection, $\delta_{SSE,max}$. For the worst case condition of combined channel bow and an SSE seismic event, $y_{o,max}$ and $\delta_{SSE,max}$ are added together.

8.1 OUTER EDGE

The maximum tensile bending stress is at the outer edge of the wing when the bending is about the centerline, see Figure 8.1.

[[

]]

Figure 8.1: Control Rod Top View Showing Channel Loads And Area For Outer Edge

[[

]]

TABLE 8.1: CONTROL ROD OUTER EDGE BENDING STRESS

LOAD TYPE	TEMPERATURE	MAXIMUM STRESS	ALLOWABLE	RATIO
TENSILE K-K	70°F[21°C]	[[	Table 4.4B	< yield str.
TENSILE K-K	550°F[288°C]	]]	Table 4.4B	2.3

8.2 INNER EDGE

In order to cause bending of the control rod centerline, the fuel channels impinge on the horizontal control rod wings (Fig. 8.2), and this load is transmitted through the tie rods out to the vertical wings.

[[

]]

Figure 8.2: Control Rod Top View Showing Channel Loads And Area For Tie Rod Weld

[[

]]

[[

]]

Figure 8.3: Cross Section Of Absorber Tube To Tie Rod Weld On Left, Sectional Properties Of Weld On Right. B = Unity Length

WELD SIZE

The minimum weld penetration for the square tube to tie rod weld is [[ ]]

[[

]]

TABLE 8.2: TUBE TO TIE ROD WELD STRESS

LOAD TYPE	TEMP	LOAD per UNIT LENGTH	WELD SIZE	MAXIMUM STRESS	ALLOWABLE	RATIO
SHEAR J-J	70°F [21°C]	[[				- -
SHEAR J-J	550°F [288°C]					- -
BENDING J-J	70°F [21°C]					- -
BENDING J-J	550°F [288°C]					- -
RESULTANT J-J	70°F [21°C]					< yield str./2
RESULTANT J-J	550°F [288°C]				]]	< yield str./2

9 STUCK ROD CONDITION

The control rod was evaluated against the capability of the FMCRD insertion load in a "stuck rod" condition. As a result, the analysis conservatively determined the maximum allowable compressive loading of the control rod.

The following table displays the results from Section 9.1 and 9.2, in all cases the yield load was limiting.

TABLE 9.1: COMPRESSIVE LOAD CAPABILITY OF CONTROL ROD

	TEMPERATURE	CRITICAL BUCKLING	YIELDING	FMCRD FORCE	RATIO
CONTROL ROD H-H	70°F[21°C]	[[		8.07kips [35.9kN]	< yield load
CONTROL ROD H-H	550°F[288°C			3.64kips [16.2kN]	< yield load
WING ONLY J-J to K-K	70°F[21°C]			8.07kips [35.9kN]	< yield load
WING ONLY J-J to K-K	550°F[288°C		]]	3.64kips [16.2kN]	< yield load

9.1 CONTROL ROD ASSEMBLY

The control rod is assumed pinned at both ends, the critical buckling load for axial compression of the control rod:

$$P_{CR} = \frac{\pi^2 EI}{L^2}$$

The corresponding yield load:

$$P_Y = \sigma_Y A_{ABSORBER\_SECTION}$$

9.2 CONTROL ROD WING

If only one wing is compressively loaded during a stuck rod condition, the possibility of buckling along the outer free edge is examined.

[[

]]

The corresponding yield load:

$$P_Y = \sigma_Y A_{ABSORBER\_SECTION\_WING}$$

10 STRESSES DUE TO LIFTING LOADS

The control rod will be subject to lifting loads during transportation and servicing. The handle was subjected to three times the weight of the control rod. The maximum weight of the control rod per Reference 6 [[ ]]

The minimum handle thickness was modeled in ANSYS with the minimum fillet weld size. Model was meshed [[

]]

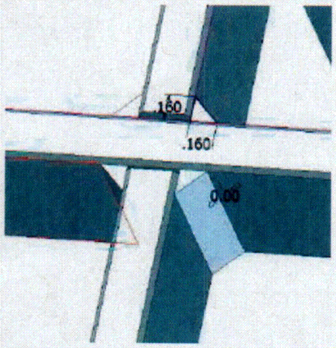

Figure 10.1: Handle Assembly Showing Fillet Weld Detail.

The control rod grapple was assumed to be similar to a typical handling grapple where the hook is .5"[13mm] thick and angled 45 from the handle wings.

C 04

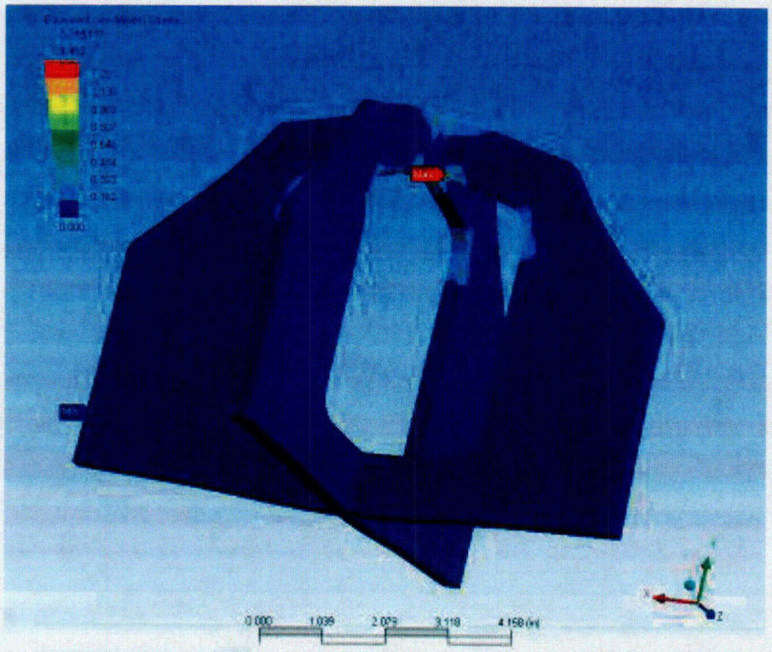

Figure 10.2: Handle Assembly Showing FEA Results And Location Of Maximum Equivalent

TABLE 10: HANDLE LIFTING STRESS

LOAD TYPE	TEMPERATURE	[[	ALLOWABLE	RATIO
TENSILE G-G	70°F[21°C]	]]	Table 4.2	< yield str.

C05

11 STRESSES DUE TO EXTERNAL PRESSURE

The absorber tube is subject to the reactor operating pressure during initial control rod lifetime. The external pressure is eventually equalized with the build up of helium gas pressure as described in Section 4.7.4 and 5.5.2. The control rod can also be subject to channel bow pressure when two channels "pinch" a control rod wing. The absorber tube is evaluated against external pressure and the combined effect of both external forces.

[[

]]

[[

]]

Figure 11.1: Square Tube External Loading, Left Is Reactor Pressure, Right Is Channel Bow.

There are two areas with high stress as shown in Figure 11.2 below.

[[

]]

Figure 11.2: Representative Absorber Tube Stress Plot From External Loading Showing Locations Of Highest Stress Intensity.

TABLE 11: ABSORBER TUBE STRESSES DUE TO EXTERNAL PRESSURE

LOAD TYPE	TEMPERATURE	[[	ALLOWABLE	RATIO
RPV PRESSURE E-E	550°F[288°C]		Table 4.4B	2.6
RPV PRESSURE + CHANNEL BOW E-E	550°F[288°C]	]]	Table 4.4B	2.3

12 HYDRAULICS

Inspection experience over 14 years at 11 different BWRs has shown the Marathon control rod is not damaged by the vibrations or cavitations set up by coolant velocities and velocity distributions in the bypass region between fuel channels.

13 STRESS AND STRAIN DUE TO B_4C BURN-UP

The absorber tube is designed to accommodate loads created by the neutron irradiation of B_4C absorber material as described in Section 5.5. The stress due to thermal loads and helium gas pressure, as well as the strain due to B_4C absorber swelling are adequate for the nuclear design life of the control rod.

13.1 STRESS DUE TO THERMAL LOADS

The thermal temperature gradient across the absorber tube wall induces thermal stress equal to:

$$\sigma_{THERMAL,550^{\circ}F} = E\alpha(\Delta T)$$

Where E and α are from Table 4.4B [[ ]]

TABLE 13.1 STRESSES DUE TO THERMAL LOADS

LOAD TYPE	TEMPERATURE	[[	ALLOWABLE	RATIO
THERMAL	550°F[288°C]	]]	Table 4.4B	< yield str.

13.2 STRESS DUE TO INTERNAL PRESSURE

The absorber tube pressure builds as the B10 is depleted. The absorber tube maximum pressure capability is determined using ANSYS. [[

]]

[[

]]

TABLE 13.2A INTERNAL PRESSURE LOADS

LOAD TYPE	TEMPERATURE	[[		RATIO
INTERNAL PRESSURE	550°F[288°C]		]]	2

[[

]]

Figure 13.1: Absorber Tube Stress Distribution Under Maximum Pressure.

[[

]]

.TABLE 13.2B ABSORBER TUBE DEPLETION [[ ]]

[[		
		]]

The nuclear analysis %B10 depletion at end of life is less than the allowable %B10 depletion. [[ ]]

13.3 STRAIN DUE TO ABSORBER SWELLING

The capsule expands as the B_4C swells due to irradiation as described in 4.7.4. [[ ]]

The absorber tube was modeled using ANSYS [[ ]]

TABLE 13.3: Absorber Tube Radial Displacement versus Maximum Tube Outer Surface Strain.

[[			
			]]

Based on radial displacement the maximum tube strain is [[ ]], which is less than the allowable [[ ]] by a ratio of 2.92.

14 LOAD COMBINATIONS

Two load combinations are considered in this control rod analyses listed as condition 1 and 2 below.

14.1 CONDITION 1 – SECTION E-E

As described in Section 5.1, SCRAM loads are highest when the control rod is inserted from the "full out" position. SCRAM can occur at the beginning of control rod life, or at the end when absorber tube pressure is highest due to helium gas release. In addition, there may be channel bow in the cell. Seismic deflection is not added to channel bow since the deflection from seismic and channel bow would most likely reduce SCRAM speed. Channel bow may also reduce scram speed, although it is conservatively assumed that the control rod terminal velocity is unchanged.

14.1.1 AXIAL STRESS

From Table 7.4 listing the maximum stress for scram.

From Table 13.2A, the absorber tube pressure limit at control rod end of life. [[

]]

[[

]]. The axial stress from elevated temperature pressure is conservatively applied to the 70°F[21°C] analysis.

[[

]]

The stress in absorber tube 11:

$$\sigma_{AXIAL} = \sigma_{SCRAM} + \sigma_{INT\_PRESSURE} + \sigma_{BENDING}$$

TABLE 14.1A: AXIAL STRESS DUE TO COMBINED LOADING CONDITION 1

TEMPERATURE	SCRAM	INTERNAL PRESSURE	DEFLECTION BENDING	COMBINED	ALLOWABLE	RATIO
70°F[21°C]	[[				TABLE 4.4B	2.18
520°F[271°C]				]]	TABLE 4.4B	2.23

14.1.2 RADIAL AND HOOP STRESSES

The pressure built up from helium gas release will exert loads on the absorber tube [[

]]

The ANSYS model that determined the maximum stress in Section 13.2 was then evaluated at the allowable pressure [[

]] The radial and hoop stresses from elevated temperature pressure are conservatively applied to the 70°F[21°C] analysis.

14.1.3 EQUIVALENT STRESS

Using the distortion energy theory, the equivalent stress can be determined.

$$\sigma = \sqrt{\frac{\left[(\sigma_{AXIAL} - \sigma_{RADIAL})^2 + (\sigma_{RADIAL} - \sigma_{HOOP})^2 + (\sigma_{HOOP} - \sigma_{AXIAL})^2\right]}{2}}$$

The location of the stress, axial node 12, would normally imply irradiation strengthening of the material. The unirradiated properties are conservatively used below.

TABLE 14.1B: STRESS DUE TO COMBINED LOADING CONDITION 1

TEMPERATURE	COMBINED	ALLOWABLE	RATIO
70°F[21°C]	[[	TABLE 4.4B	2.13
520°F[271°C]	]]	TABLE 4.4B	1.87

[[

]]

14.2 CONDITION 2 – SECTION DD and F-F

As described in Section 5.1, SCRAM loads are highest when the control rod is inserted from the "full out" position. SCRAM can occur at the beginning of control rod life, or at the end when

absorber tube pressure is highest due to helium gas release. These loads can combine at either the absorber section handle weld or connector weld.

The stresses in the weld change during SCRAM depending on the absorber tube status at beginning of life or end of life. To depict the loading within the welds designated as A1, A2 and A3 as shown in Figure 7.5, Figure 14.1 shows 4 different loading conditions for the absorber section to handle and connector welds. In Figure 14.1, black arrows are the applied load, the gray arrows are the tensile or shear reactions and the gray lines are load flow lines. The key in the connector load conditions is the proportion of load carried by either A2 or A3. [[ ]]

Figure 14.1 SCRAM figure shows the connector to absorber section weld with A1 in shear, A2 and A3 in tension. [[

]]

During SCRAM the absorber section to handle weld is loaded differently. [[

]] The load carried by A2 alone was conservatively considered in Section 7.5.

Figure 14.1 internal pressure figure is without SCRAM. In this condition welds A1 and A2 will transmit the pressure load with weld A2 in tension and A1 in shear. [[

]]

[[ ]]

[[

]]

Figure 14.1: Load Combinations On The Absorber Section To Handle And Connector Welds.

Figure 14.1 "SCRAM low + Internal Pressure" is for discussion purposes. [[

]]

Figure 14.1 "SCRAM + Internal Pressure" figure depicts inoperative buffer scram and EOL internal absorber tube pressure. An explanation of the loads:

[[

]]

TABLE 14.2A: LOADS ON ABSORBER SECTION TO HANDLE AND CONNECTOR WELDS, (-) IS TENSION AND (+) IS COMPRESSION.

CONDITION	SECTION	TEMP	A1 shear	A2	A3
SCRAM	Connector	70°F[21°C]	[[		
SCRAM	Connector	550°F[288°C]			
SCRAM	Handle	70°F[21°C]			
SCRAM	Handle	550°F[288°C]			
Internal Pressure	Handle, Connector	70°F[21°C] 550°F[288°C]			
SCRAM + IP	Connector	70°F[21°C]			
SCRAM + IP	Connector	550°F[288°C]			
SCRAM + IP	Handle	70°F[21°C]			
SCRAM + IP	Handle	550°F[288°C]			]]

Treating the weld as a line, the load "*f*" is expressed in kips/in[kN/mm]. The weld length and size are as follows:

[[

]]

The allowable stress is based on the minimum material strength of those materials making up the absorber section to handle weld fusion zone. See Section 7.5 for the material description.

TENSILE LOAD

Using minimum weld length and effective weld penetration:

$$\sigma_{TENSILE,WELD,A} = \frac{f_{SECTION,F-F}}{weld\_size}$$

SHEAR LOAD

Using minimum weld length and effective weld penetration:

$$\tau_{SHEAR,WELD,B} = \frac{f_{SECTION,F-F}}{weld\_size}$$

TABLE 14.2B: ABSORBER SECTION TO HANDLE/CONNECTOR WELD STRESS

LOAD TYPE - WELD	TEMP	*f*	WELD SIZE	MAXIMUM STRESS	ALLOWABLE	RATIO
SHEAR – A1 Sect F-F	70°F[21°C]	[[				2.34
SHEAR – A1 Sect F-F	520°F[271°C]					2.15
TENSILE – A2, sect D-D	70°F[21°C]					2.62
TENSILE – A2, sect D-D	520°F[271°C]				]]	< yield str.

14.3 CONDITION 3 – SECTION E-E

Absorber tube strains were evaluated during a seismic event near the end of control rod life when absorber burn-up helium gas pressure is highest.

The approach for seismic is described in Section 8. In order to cause bending of the control rod centerline, the fuel channels impinge on the horizontal control rod wings (Fig. 14.2), and this load is transmitted through the tie rods out to the vertical wings.

[[

]]

Figure 14.2: Control Rod Top View Showing Channel Loads And Section S-S On The Outside Edge Of Tube 1.

The shear load and moment load were input into an ANSYS finite element model to determine the stresses [[ ]] Additional conservatism is input into the analysis by shifting the control rod to one side of the fuel cell, thereby increasing the distance A and subsequently the moment arm. [[ ]]

[[

]]

Figure 14.3: Model Showing Bending Loads

[[

]]

[[

]]

Figure 14.4: Model Showing Results For Condition 3 [[

]]

[[

]] The model was run and the highest of the element or nodal stress intensities were reported.

TABLE 14.3: STRESS DUE TO COMBINED LOADING CONDITION 3

TEMPERATURE	[[	ALLOWABLE	RATIO
520°F[271°C]	]]	TABLE 4.4B	1.18

[[

]]

15 FATIGUE

Possible control rod fatigue under cyclic SCRAM, seismic and thermal load conditions will be considered in this section. The analysis approach uses Miner's Rule for cumulative fatigue damage, where

$$\sum \frac{n_i}{N_i} < 1.0$$

to avoid fatigue cracking due to accumulative damage. The allowable number of fatigue cycles is determined from Reference 3's Figure I-9.2.1.

As shown below, with conservative assumptions, the fatigue usage is below 1.0.

15.1 SCRAM

The highest stress during scram was [[ ]] as shown in Table 7.1. At 70°F[21°C] the stress was [[ ]]

[[ ]]

The highest weld stresses were [[ ]] during a load combination of SCRAM and high internal absorber tube pressure. At 70°F[21°C] the stress was [[ ]]

[[ ]]

15.2 SEISMIC

The lowest margin during a seismic event was [[ ]]during a load combination 3 of seismic deflection, channel bow and end of life 304S absorber tube pressure as shown in Table 14.3. At 550°F[288°C] the stress was [[ ]]

[[

]]

15.3 THERMAL

The thermal gradient across the absorber tube is [[
]] as shown in Section 13.1. [[
]]

15.4 SAME LOCATION

Near control rod end of life [[ ]] may contain two high stress areas under different type loading conditions. [[
]] the stresses will be conservatively added as though the stresses occur at the same location. Load combination 1 was scram loading with channel bow and end of life 304S absorber tube pressure as shown in Table 14.1B. At 70°F[21°C] the stress was [[
]]

Using the result from combination 3 above and adding combination 1 applying the stress range to the Sa-N curve:

[[

]]

REFERENCES

1.) GE Drawing 105E4220 Rev. 0 "Control Rod".
2.) 26A6642AP Rev. 1 "ESBWR Design Control Document", Tier 2, Chapter 4C.
3.) 2001 Edition, 2003 Addenda, ASME Boiler and Pressure Vessel Code, Section III.
4.) NEDE-33243P Rev. 0 "ESBWR Marathon Control Rod Nuclear Design Report", Licensing Topical Report.
5.) 26A6647 Rev. 1 "Seismic Analysis of Reactor/Fuel Building Complex" Appendix C.
6.) 26A6631 Rev. 0 "Reactor Pressure Vessel System" Design Specification.
7.) Regulatory Guide 1.29 "Seismic Design Classification".
8.) NEDC-33240P Rev. 0 "GE14E Fuel Assembly Mechanical Design Report".

ENCLOSURE 3

MFN 06-183

Affidavit

General Electric Company

AFFIDAVIT

I, George B. Stramback, state as follows:

(1) I am Manager, Regulatory Services, General Electric Company ("GE") and have been delegated the function of reviewing the information described in paragraph (2) which is sought to be withheld, and have been authorized to apply for its withholding.

(2) The information sought to be withheld is contained in the GE proprietary report, NEDE-33244P, *ESBWR Marathon Control Rod Mechanical Design Report*, Class III (GE Proprietary Information), June 2006. The proprietary information is delineated by a double underline inside double square brackets. Figures and large equation objects are identified with double square brackets before and after the object. In each case, the superscript notation {3} refers to Paragraph (3) of this affidavit, which provides the basis for the proprietary determination.

(3) In making this application for withholding of proprietary information of which it is the owner, GE relies upon the exemption from disclosure set forth in the Freedom of Information Act ("FOIA"), 5 USC Sec. 552(b)(4), and the Trade Secrets Act, 18 USC Sec. 1905, and NRC regulations 10 CFR 9.17(a)(4), and 2.790(a)(4) for "trade secrets" (Exemption 4). The material for which exemption from disclosure is here sought also qualify under the narrower definition of "trade secret", within the meanings assigned to those terms for purposes of FOIA Exemption 4 in, respectively, Critical Mass Energy Project v. Nuclear Regulatory Commission, 975F2d871 (DC Cir. 1992), and Public Citizen Health Research Group v. FDA, 704F2d1280 (DC Cir. 1983).

(4) Some examples of categories of information which fit into the definition of proprietary information are:

a. Information that discloses a process, method, or apparatus, including supporting data and analyses, where prevention of its use by General Electric's competitors without license from General Electric constitutes a competitive economic advantage over other companies;

b. Information which, if used by a competitor, would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing of a similar product;

c. Information which reveals aspects of past, present, or future General Electric customer-funded development plans and programs, resulting in potential products to General Electric;

d. Information which discloses patentable subject matter for which it may be desirable to obtain patent protection.

The information sought to be withheld is considered to be proprietary for the reasons set forth in paragraphs (4)a., and (4)b, above.

(5) To address 10 CFR 2.390 (b) (4), the information sought to be withheld is being submitted to NRC in confidence. The information is of a sort customarily held in confidence by GE, and is in fact so held. The information sought to be withheld has, to the best of my knowledge and belief, consistently been held in confidence by GE, no public disclosure has been made, and it is not available in public sources. All disclosures to third parties including any required transmittals to NRC, have been made, or must be made, pursuant to regulatory provisions or proprietary agreements which provide for maintenance of the information in confidence. Its initial designation as proprietary information, and the subsequent steps taken to prevent its unauthorized disclosure, are as set forth in paragraphs (6) and (7) following.

(6) Initial approval of proprietary treatment of a document is made by the manager of the originating component, the person most likely to be acquainted with the value and sensitivity of the information in relation to industry knowledge. Access to such documents within GE is limited on a "need to know" basis.

(7) The procedure for approval of external release of such a document typically requires review by the staff manager, project manager, principal scientist or other equivalent authority, by the manager of the cognizant marketing function (or his delegate), and by the Legal Operation, for technical content, competitive effect, and determination of the accuracy of the proprietary designation. Disclosures outside GE are limited to regulatory bodies, customers, and potential customers, and their agents, suppliers, and licensees, and others with a legitimate need for the information, and then only in accordance with appropriate regulatory provisions or proprietary agreements.

(8) The information identified in paragraph (2), above, is classified as proprietary because it contains detailed ESBWR design information and dimensional information regarding the Marathon Control Rod developed by GE over a period of several years at a cost of over one million dollars.

The development of the testing and evaluation process along with the interpretation and application of the testing and analytical results is derived from the extensive experience database that constitutes a major GE asset.

(9) Public disclosure of the information sought to be withheld is likely to cause substantial harm to GE's competitive position and foreclose or reduce the availability of profit-making opportunities. The information is part of GE's comprehensive BWR safety and technology base, and its commercial value extends beyond the original development cost. The value of the technology base goes

beyond the extensive physical database and analytical methodology and includes development of the expertise to determine and apply the appropriate evaluation process. In addition, the technology base includes the value derived from providing analyses done with NRC-approved methods.

The research, development, engineering, analytical and NRC review costs comprise a substantial investment of time and money by GE.

The precise value of the expertise to devise an evaluation process and apply the correct analytical methodology is difficult to quantify, but it clearly is substantial.

GE's competitive advantage will be lost if its competitors are able to use the results of the GE experience to normalize or verify their own process or if they are able to claim an equivalent understanding by demonstrating that they can arrive at the same or similar conclusions.

The value of this information to GE would be lost if the information were disclosed to the public. Making such information available to competitors without their having been required to undertake a similar expenditure of resources would unfairly provide competitors with a windfall, and deprive GE of the opportunity to exercise its competitive advantage to seek an adequate return on its large investment in developing these very valuable analytical tools.

I declare under penalty of perjury that the foregoing affidavit and the matters stated therein are true and correct to the best of my knowledge, information, and belief.

Executed on this 16th day of June 2006.

George B. Stramback
General Electric Company